PROJECT SUMMARY

TITLE:

Placer Potential of Fox Island River and East-Central Port au Port Bay: A Preliminary Assessment

OBJECTIVES:
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1. provide a first approximation of the placer mineral potential within the study area and,

2. develop preliminary genetic model(s) for fluvial and marine placer formation in the study area.

METHODOLOGIES:

River, beach and nearshore sediments were mapped and sampled at regular intervals. Geophysical profiling of the overburden sediment was attempted. The textural, mineralogical and geochemical characteristics of the surficial sediment facies were determined.

CONCLUSIONS:
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1. Six textural facies were defined and seen to be spatially controlled by varying hydraulic regimes and the character of primary and secondary sediment sources.

2. The distribution of heavy minerals reflects the relative effectiveness of enrichment processes which are in themselves largely controlled by the hydraulic regime and the character of the host facies. Reworked lag concentrations of heavy minerals occur in gravel interstices of the upper river wheras processes of differential entrainment serve to concentrate placer minerals in sands on the beach and in the offshore.

3. The highest heavy mineral concentrations are found in beach sediments (up to 98 total weight %) as discrete laminae and in modern marine sands(up to 32 total weight %); the lowest concentrations are found in the aggrading portions of the river mouth.

4. The mineral commodity with the most apparent economic promise is chromite. The chromic oxide content of the sediments is found to be proportional to the overall heavy mineral content and ranges from <.1 to 6 weight percent.

4. Platinum group element concentrations were only slightly above background altough further bulk sampling is needed before a conclusive statement can be made.

5. The greatest placer potential in the study area is the coastal beaches and offshore region. Altough it is known that large volumes of sediment have been flushed into Port au Port Bay, the temporal and spatial effectiveness of concentrating processes remains inadequately understood.

PRESENTATION OF RESULTS:

The contract report presented here-in is an expanded version of that submitted to the Newfoundland Department of Mines Current Research, 1988 edition. Included in this document is a descriptive discussion of the geological character of the source-conduit-sink system within the study area and it's relevance to placer formation. A section on recommendations for further work is followed by an appendices of analytical data and a map of sample locations.

INTRODUCTION

A placer deposit is a concentration of economically valuable detrital mineral grains which are formed by mechanical processes (most commonly running water). Placer minerals include "heavy heavy minerals" (specific gravity, 6.8-21) such as native gold, native platinum and cassiterite ; the "light heavy minerals" (specific gravity, 4.2-5.3), chromite, rutile, ilmenite zircon, and monazite; and the gem minerals (S.G. 2.9-4.1), diamond, rubies and sapphires (Emery and Noakes, 1968). Placer deposits have historically provided a major share of the world's gold, platinum, diamonds, ilmenite, rutile, zircon, and tin.

Despite their economic importance, there has been little sedimentary research in placer genesis (Slingerland and Smith, 1986). This is particularly true in glaciated terrains where the effects of glacial and glacially-influenced sedimentary processes on placer formation are poorly understood. The site chosen for the present research (Fox Island River/Port au Port Bay, western Newfoundland; Figure 1) was extensively glaciated during the Quaternary, and is characterized by the four geologic criteria necessary for placer formation:

1. source - ophiolitic rocks containing chromite and platinum group elements,

2. liberation mechanism - glacial, periglacial, and postglacial processes resulting in the mechanical attrition of bedrock and contemporaneous dispersal and deposition of large volumes of sediment,

3. conduit (transport pathway) - Fox Island River and associated tributaries, and

4. depositional sink - Port au Port Bay.

The study area is therefore ideally suited as a test site in which to identify the various controls on placer formation in a glaciated terrain. The objective of the present study is thus to provide a preliminary assessment of the placer potential of Fox Island River and east-central Port au Port Bay with a view to the development of a preliminary genetic model and delineation of favourable sites for further work.

GEOLOGY OF THE SOURCE ROCKS

The suite of rocks represented in the Fox Island River drainage basin include (Williams,1975):

1. inliers of Precambrian basement

2. an autochthonous Cambro-Ordovician carbonate succession,

3. a Middle Ordovician allocthonous clastic shelf succession and ophiolitic suite

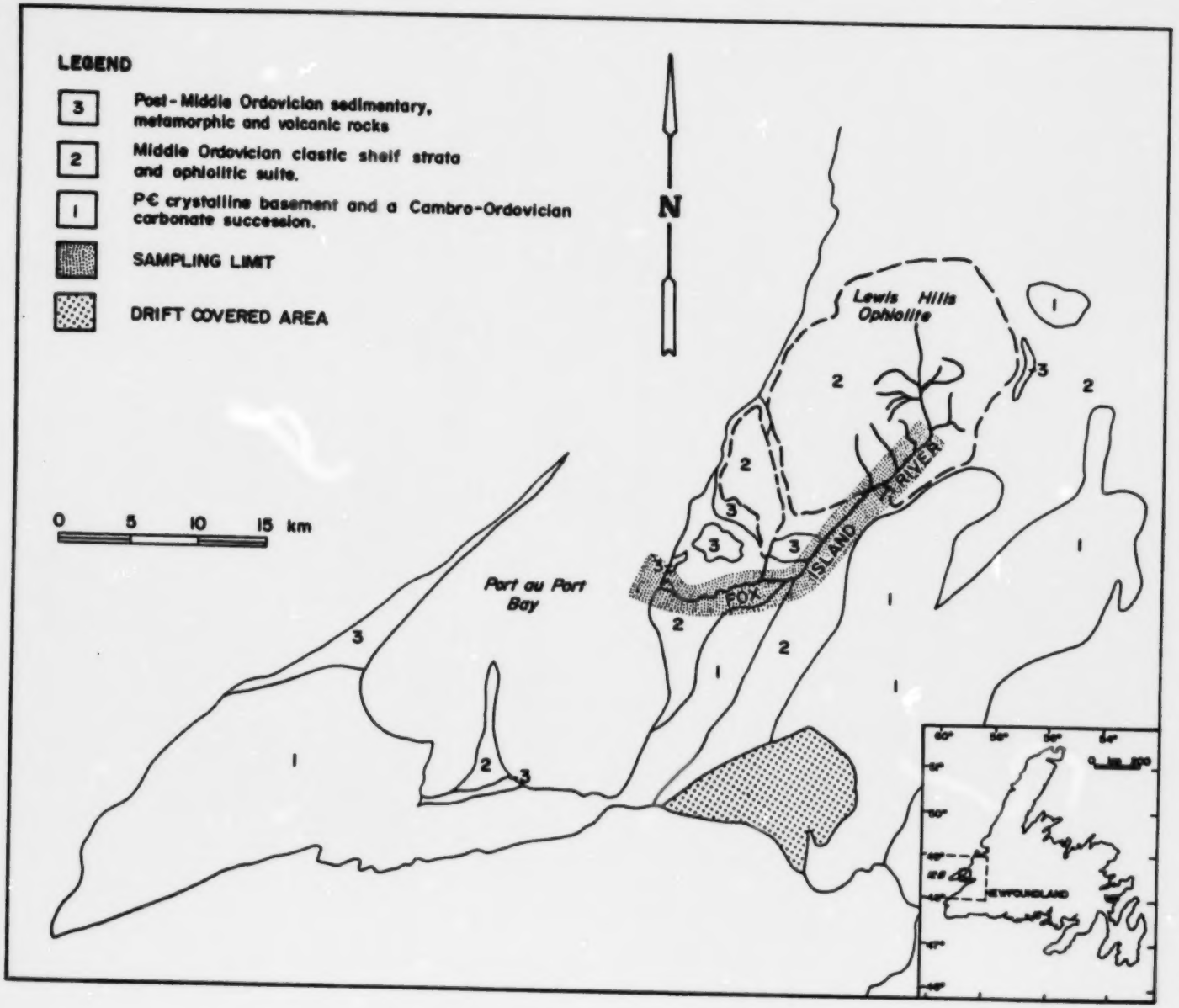


Figure 1: Location and geologic setting of the study area.

4. neoautocthonous schists and volcanic rocks and Carboniferous cover rocks.

Within the present study area the Lewis Hills ophiolitic rock suite forms the highest structural slice in a series of stacked thrust sheets which are interpreted to record the evolution and destruction of the ancient continental margin of North America (Williams, 1975). Discrete lithologic assemblages (e.g., harzburgite and wehrlite) within the ophiolite are characterized by numerous discontinuous layers of disseminated and massive chromite. Chromite grains are generally euhedral to subhedral, < 2 mm in diameter, and grade at approximately 36-52 weight percent $Cr_2 O_3$ in the richest sections (Dunsworth et al, 1984; Snelgrove, 1934).

The geological significance and economic potential of platinum-group elements (PGE) in ophiolitic complexes has recently received considerable attention (e.g., Legendre and Auge, 1986). Although no economic lode deposits have been discovered, platiniferous placer deposits are known to occur in association with ophiolitic suites (Ford, 1981). Given the known, albeit very low grade occurrences of PGE in the Lewis Hills Ophiolite (Page and Talkington, 1984), there exists a potential for associated PGE-bearing placer deposits within the study area.

QUATERNARY GEOLOGY: LIBERATION MECHANISM AND SECONDARY SOURCE

Glacial, periglacial and postglacial processes are of considerable importance to the liberation of placer minerals due to their effects on bedrock attrition and overall sediment availability. Glaciated terrains are generally characterized by a regolith of mechanically weathered debris which is the product of subglacial quarrying and abrasion, erosion by running water, and freeze-thaw activity. These processes release large volumes of sediment ranging in size from silt-clay to house-sized boulders.

Within the study area maximum ice extent during the Late Wisconsin was very near present coastal limits (Grant, 1977). Of the three glacial units recognized in southwestern Newfoundland, only the Robinson's Head Drift occurs in the study area (Brookes, 1974). This unit is considered to be a product of a local ice readvance (12,600 $\pm$ 140 yrs. B.P.), and is characterized by a sheet of coarse till (Brookes, 1974).

Sediments exposed in the incised river banks of Fox Island River and in wave-cut terraces along coastal sections reveal a complex sequence of Quaternary events. Facies types identified include (no chronological ordering): diamictons (basal till and/or resedimented morainal material), pro- and postglacial colluvial, fluvial and deltaic sands and gravels, and raised marine silts and clays.

Isostatic readjustment subsequent to the Late Wisconsin recession resulted in a 60m drop in relative sea level dating from 14,000 to 6,000 yrs B.P. Relative sea level has risen about 14m from 6,000 yrs B.P. to present (Brookes et al., 1985).

A CHARACTERIZATION OF THE CONDUIT AND SINK

Given the presence of source (Lewis Hills ophiolite and glacial sediments) and a liberation mechanism (glacial and postglacial mechanical weathering), an attempt was made to characterize the transport corridor (Fox Island River) and depositional sink (Port au Port Bay). To this end, a detailed surficial mapping and sampling program with select geophysical profiling was undertaken; a description of field and analytic procedures and preliminary results follows.

METHODOLOGIES

Mapping and Sampling Program

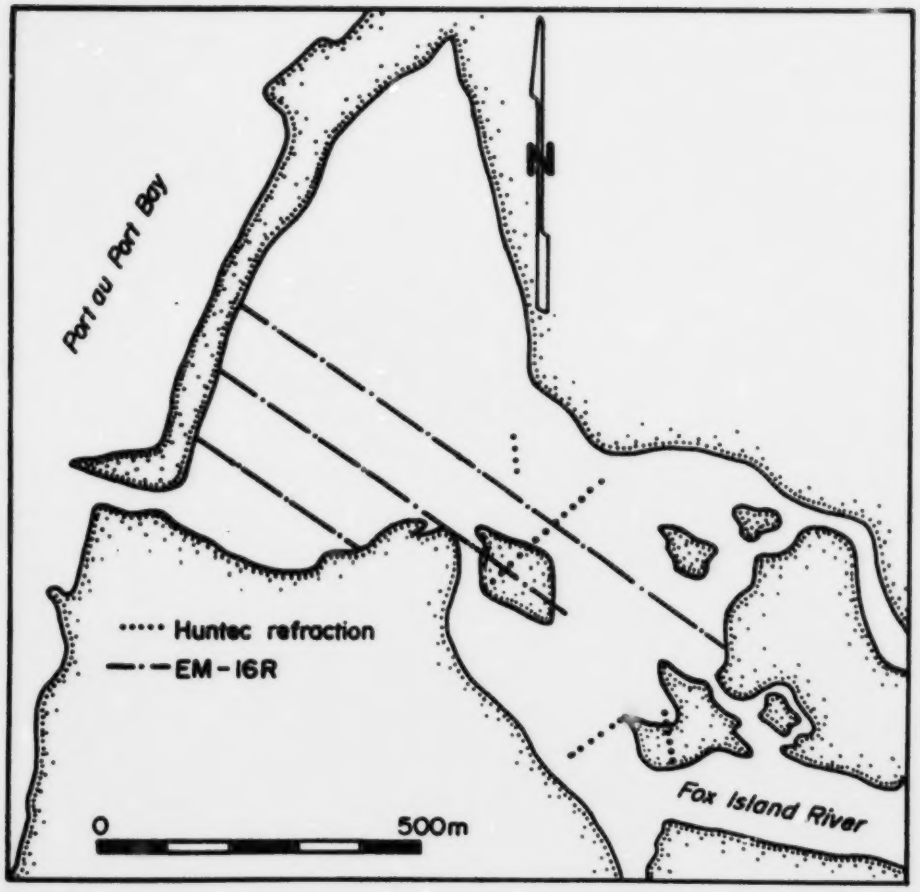
Surficial sediments from the bed of Fox Island River, the beaches adjacent to the river and in the offshore zone (to <20m water depth) fronting the river mouth were mapped and sampled for textural and mineralogical analyses. A total of 312 surficial samples (average weight of 1 kg) were collected: 35 in Port au Port Bay, 25 from the coastal beach and 252 from Fox Island River. Representative samples from major glacial sequences were collected from incised river banks and wave-cut terraces. Finally, three bulk samples (weighing about 30 kg) from the beach sediment, glacial outwash and diamicton were collected for analyses of noble metals.

All river samples were collected on a coarse line grid of 250 m with sample intervals of 100m. The samples were restricted to <4 mm size fraction as the very coarse cobble-boulder lag which characterizes the river bed precluded any form of bulk sampling for textural analysis. The potential loss of fines resulting from subaqueous sampling in the river was minimal due to extreme low water conditions which allowed sampling of exposed riverbed sediments.

Offshore surficial grab samples were collected by SCUBA divers on a coarse line grid of 1km with sample intervals of 250m. Sample positioning, accurate to within ±50 m, was determined by fin and compass. A hand trowel was used for collection of offshore samples. Depth limitations on SCUBA divers restricted sample collection to <20 m water depth.

Geophysical Program

The geophysical program was comprised of VLF-resistivity, hammer refraction, seismic and sonic subbottom profiling surveys. The total VLF-resistivity coverage was 1.9 km using 10 m stations (Figure 2). A dual channel Huntec system with a source-receiver station of 2 m was used in the collection of 0.5 km of seismic data (Figure 2). Each of the two geophones were used separately over the same area and then both used simultaneously in a reverse profile: this repetition was required for the



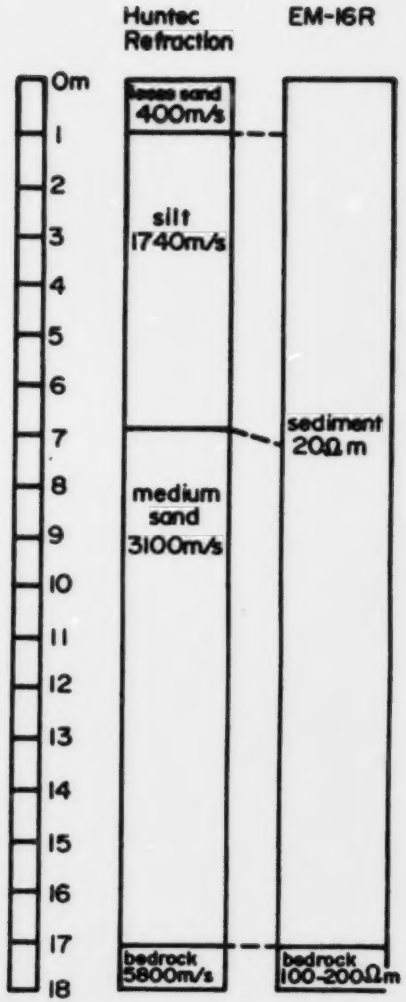


Figure 2: Geophysical profiles.

detection of dipping or ghost layers in the subsurface.

A Raytheon 1000X dual frequency subbottom profiler was used in the nearshore area off the mouth of Fox Island River. Approximately 5 km of line were surveyed. The quality of the data was poor because the acoustically hard seabed in the area (coarse sands and gravels) caused considerable scattering of the signal and a generally incoherent response.

Laboratory Analysis

Analysis of samples was selective and based on the criteria of uniform geographic spacing and inferred geomorphic controls (i.e., where flow velocity variations occur within the river). Twenty river bed, three beach, and thirty-three offshore samples were chosen for textural analysis. Samples were dried, split and sieved through a bank of seven sieves measuring 0.063 mm, 0.106 mm, 0.25 mm, 0.5 mm, 1.0 mm, 2.0 mm and 4.0 mm.

Heavy mineral separation of both the 0.063 mm to 0.25 mm and >0.25 mm to 1.0 mm size fractions were carried out on 19 offshore samples, 2 beach samples, and 44 river samples using a combination of gravity and centrifuge techniques. In addition, size fractions retained on the 0.5 mm, 0.25 mm, 0.106 mm and 0.063 mm sieves of one offshore, one beach, and one riverbed sample were individually separated in order to identify any mineralogical partioning by size. Polytungstate, a nontoxic, water-soluble heavy liquid (specific gravity of about 2.8 g/cm^3), was used in all heavy mineral analyses.

Petrographic examination of selected heavy residues was complimented by energy dispersive X-ray analyses of constituent mineral species. DCP emission spectrometry (performed on a contractual basis by Nuclear Activation Services Ltd.) was used for total metal analyses of the sand (0.063 mm to 1.0 mm) fraction of 30 samples. Analyses of noble metals was completed using ICP mass spectrometry.

RESULTS AND INTERPRETATION

Geophysics

Four stratigraphic horizons, as determined through graphic velocity calculations of seismic traces, were identified near the mouth of Fox Island River. An interpretation of sediment lithology (Figure 2), is based on velocity ranges for known sediment types. The resistivity data did not provide the necessary differentiation of sedimentary horizons but did confirm the depth to bedrock.

Facies Characterization

The Fox Island River/Port au Port Bay system consists of three general depositional environments: offshore, beach, and river. Each environment is characterized by discrete facies types of which six have been delineated on the basis of textural character, in situ visual descriptions and spatial distribution; facies O1, O2, and O3 are found in the offshore zone; facies B1 and B2 characterize the beach deposits; and

facies R1 characterizes Fox Island River sediments.

Facies O1 occurs in water depths >10 m (Figure 3). It consists of well-sorted, medium sand with <3 weight percent gravel and no clay or silt. Ephemeral current ripples and abundant sand dollars are present. Facies O1 is interpreted to represent modern marine sands undergoing active transport through the influence of waves and tidal currents.

Facies O2 is a poorly sorted, sandy gravel found in water depths ranging from <15 m to the intertidal zone (Figure 3). The sand component of this facies, ranging in content from 18 weight percent to 67 weight percent, is generally entrapped within gravel/cobble interstices. Cobbles range up to 8 cm in diameter and are generally well rounded. The gravel bed is inhabited by different varieties of flora and fauna suggesting overall gravel immobility. On this basis, facies O2 may be interpreted to represent a wave-reworked, lag deposit derived from glacial sediments.

Facies O3 is a well-sorted, medium sand which blankets gravel and cobbles (Figure 3). This facies is found in water depths of <3 m and is restricted in occurrence to the lee side of a protruding subaqueous sand spit suggesting deposition by longshore currents.

Facies R1 is found within the confines of the Fox Island River and is characterized by a surficial pebble-cobble lag armour with interstitial sands and isolated sand lenses. A general trend of decreasing boulder/cobble size downriver is observed with many local variations related to changes in bedrock lithology, presence of talus slopes and character of the incised glacial sediments. Grain size distributions of the <2 mm size fraction vary unsystematically downriver. Near the mouth of the river facies R1 is dominated by sands and gravels which form elongate bars with superimposed current ripples.

Facies B1 is characterized by unimodal well-sorted supratidal sands. Facies B2 is a moderately sorted, intertidal pebble armour.

Heavy Minerals

The heavy mineral suite within the study area is mineralogically immature, consisting of, in order of decreasing abundance, opaques, garnet, pyroxene, amphibole, olivine and minor rutile, zircon, staurolite and epidote. Textural constraints on mineralogy include:

1. an increase in total heavy mineral content with decreasing grain size,
2. an increase in the abundance of zircon and opaques with a decrease in grain size and,
3. a decrease in the abundance of olivine with a decrease in grain size.

Preliminary examination of the opaque minerals (through energy dispersive

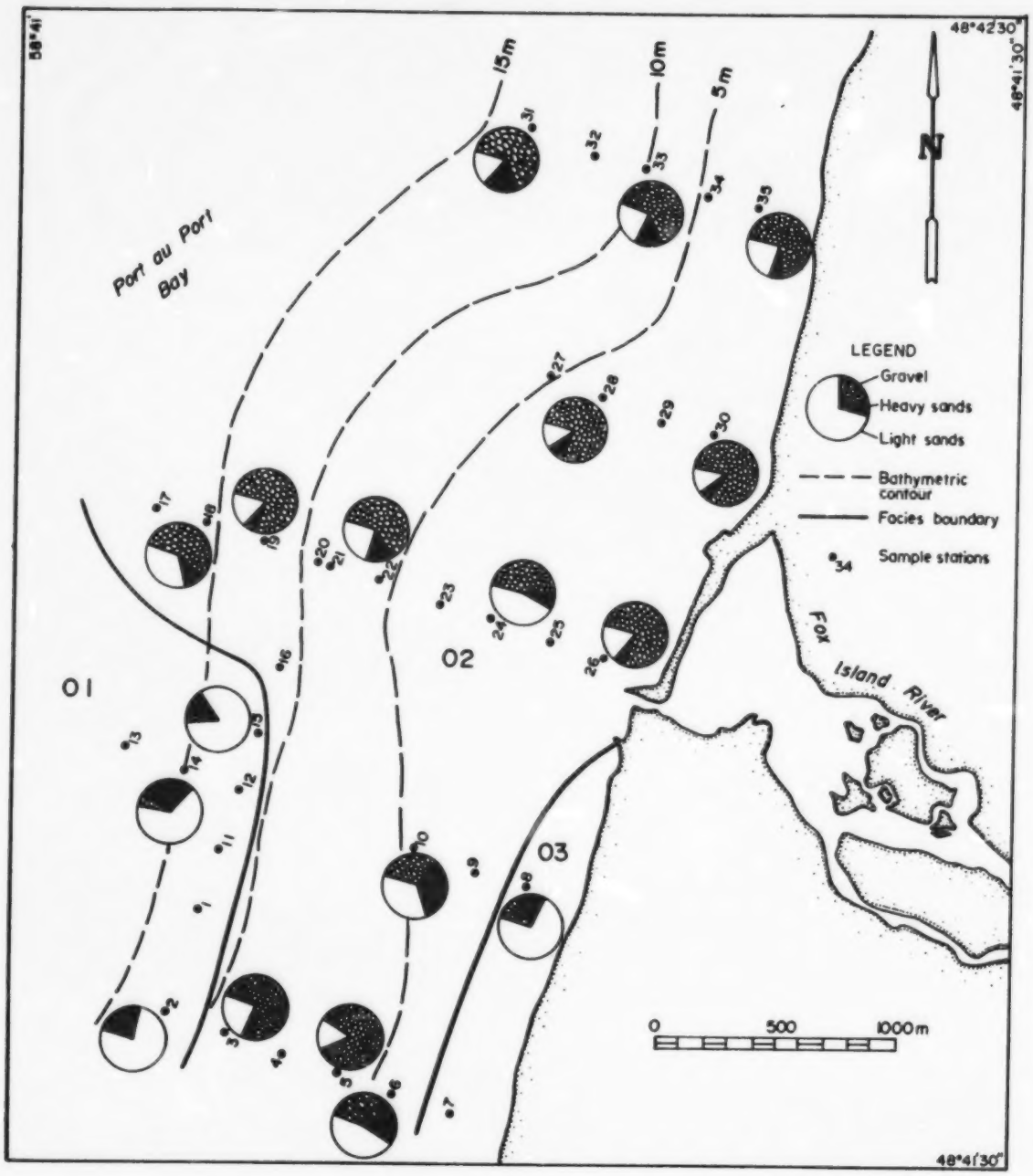


Figure 3: Textural facies distribution and heavy mineral abundance in east-central Port au Port Bay.

X-ray analysis) reveals an abundance of chromite (20-40 weight percent of the opaque minerals) followed by magnetite, ilmenite and minor sulphide phases. Cr_2O_3 content of the chromite varies between 35-55 weight percent.

The spatial variation of heavy mineral concentrates within the sand fraction (0.063 mm to 1.00 mm) of the offshore, beach, and river facies is illustrated in Figures 3 and 4. Within facies R1 sediments, heavy mineral abundances decrease downriver, probably reflecting both distance from source (Lewis Hills Ophiolite) and increased dilutional effects of aggradational processes in the lower reaches of the river. In contrast, the upper river is dominated by erosional processes which serve to enhance heavy mineral enrichment through entrapment of grains in gravel interstices (Figure 4).

The supratidal beach sediments (facies B1) are characterized by discrete heavy mineral laminae with concentrations reaching 98 total weight percent (Figure 4). Heavy mineral-rich laminae range in thickness from 2 mm to 10 mm and are separated by 10 mm to 100 mm of clean quartzofeldspathic sand. These heavy mineral occurrences are typical of beach placers and generally result from grain segregation within bedflow during wave backwash, and in this case, during storm events. Heavy mineral concentrations within the intertidal zone (facies B2) are much less, averaging 18 weight percent.

The concentration of heavy minerals detected in an analysis of one offshore facies O3 sediment (see figure 3) measures 18 total weight percent. This concentration may have formed through either differential entrainment (i.e., selective transport of light grains resulting in a residual lag of heavy minerals) or selective grain settling. Facies O3 sands are present only as a very thin surface veneer.

Facies O2 sediments exhibit a large variation in heavy mineral content, ranging from 4 total weight percent to 32 total weight percent. Anomalous concentrations of heavy minerals most probably formed as a result of lag entrapment within gravel interstices. The cause of the unsystematic heavy mineral distribution may be attributed to local variations in cobble/boulder size coupled with spatial variability in sediment supply.

Facies O1 exhibits the highest overall heavy mineral content (excepting the supratidal beach) ranging up to 32 total weight percent. The operative enrichment process is probably differential entrainment through wave and tidal reworking.

Geochemistry

The relative concentrations of Cr, Fe, Mg and Ti in the sand fraction (0.063 mm to 1.00 mm) of select offshore and river sediments are listed in Table 1; normalized plots illustrating the spatial distribution of these elements are provided in Figures 5a and 5b. Several observations can be made:

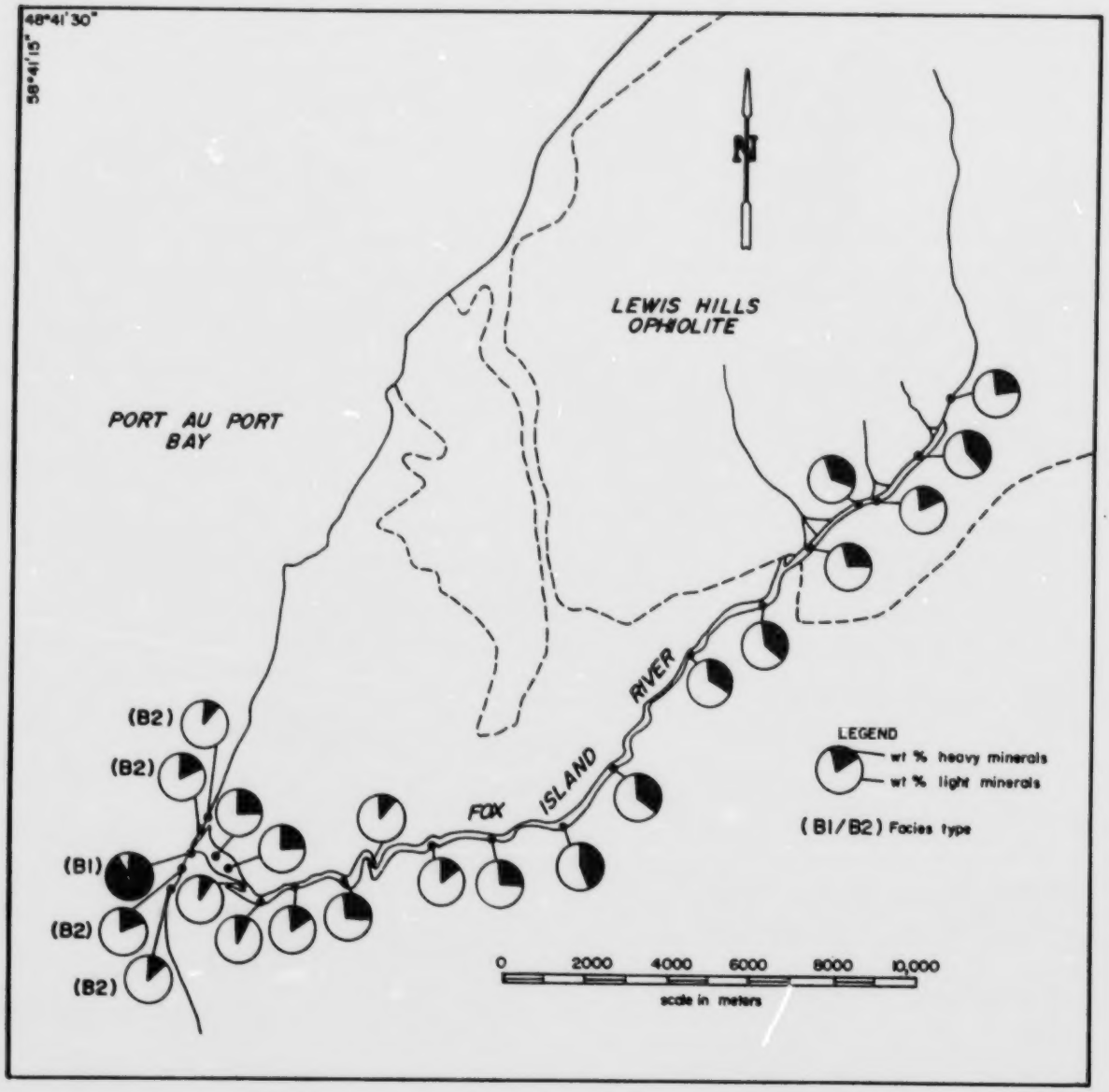


Figure 4: Heavy mineral abundances (.065 mm to 1.00 mm sand fraction) in Fox Island River and the adjacent coastal beach.

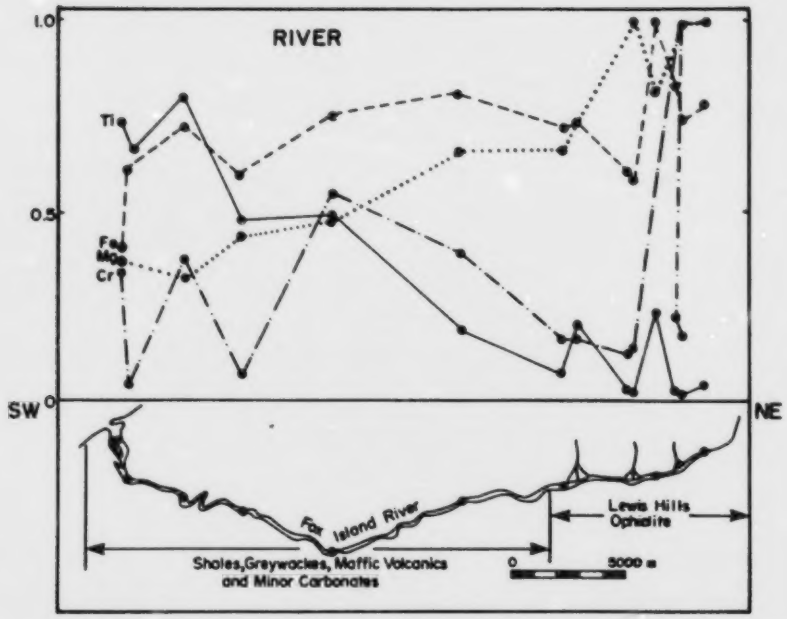


Figure 5a: Normalized plot of the spatial distribution of Ti, Cr, Fe, and Mg, in Fox Island River.

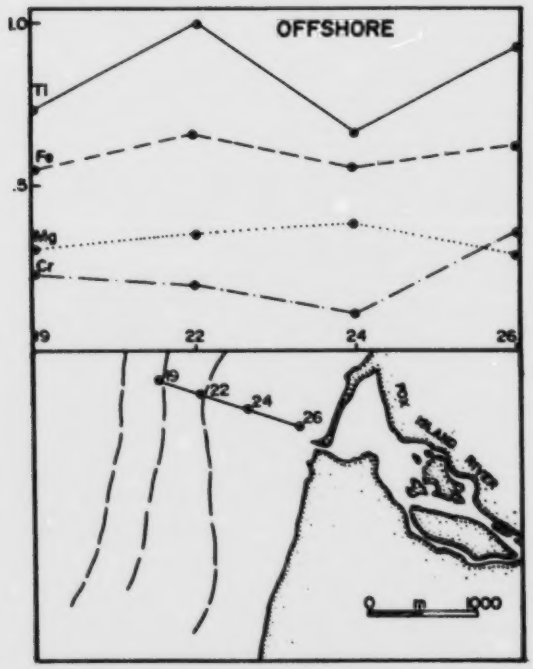


Figure 5b: Normalized plot of the spatial distribution of Ti, Cr, Fe, and Mg, in east-central Port au Port Bay.

- Mg and Ti content in the river sediments reflect local changes in bedrock lithology; Mg decreases away from the Lewis Hills ophiolite, Ti increases down river where volcanic and metasedimentary rocks.

- Cr content of the river and offshore sediments varies unsystematically and is spatially correlative with Fe reflecting the high iron/chromium content of spinels.

- within the offshore sediments all element concentrations are less variable (Table 1) reflecting more uniform enrichment processes and minimal primary source-related biases.

An analysis of a discrete heavy mineral laminae within the supratidal beach zone (facies B1) measured 67,000 ppm Cr, 130,000 ppm Fe, 40,000 ppm Mg and 5,200 ppm Ti. In contrast, a bulk sample from the intertidal sediment (facies B2) measured 310 ppm Cr, 41,0000 ppm Fe, 45,000 ppm Mg and 1,600 ppm Ti.

Table 1. Sediment Geochemistry

	Cr		Fe		Mg		Ti	
	river	offshore	river	offshore	river	offshore	river	offshore
min. (ppm)	750	1800	48000	44000	62000	52000	30	1000
max. (ppm)	18000	6500	83000	55000	210000	83000	1200	1500
ave. (ppm)	5000	3583	59867	49500	139733	67917	481	1266
C. V. (%)	87	38	16	6	40	15	96	16

C. V. - coefficient of variation

DISCUSSION: A GENETIC MODEL FOR PLACER DEVELOPMENT

The distribution and preservation of heavy mineral placer deposits is dependent on temporal variations in depositional environments and overall sediment availability. Exploration strategies for heavy mineral placers in the present study area, and in glaciated terrains as a whole, require that genetic models be formulated to trace the dispersal path of placer minerals. For the purpose of the present study, a sequence of simplified conceptual models are presented in an attempt to trace the contemporaneous dispersal of chromite and associated heavy minerals in both the fluvial(

Figures 6-8) and coastal/marine(Figures 9-11) environment. The models are based primarily on reported glacial style (Brookes,1974; Grant,1977), sea level history (Brookes et al,1986), observed field relations and initial sediment analysis as presented in this report. Model assumptions include:

1. the study area was characterized by alpine-style glaciation which was confined to the major trunk valley (as supported by the observed local dispersal of pebbles and by the model proposed by Grant,1977),

2. the maximum areal extent of Late Wisconsin ice was near present coastal limits and occurred at approximately 14,000 yrs. B.P.(Grant,1977),

3. the Late Wisconsin relative sea level maximum occurred at approximately 14,000 yrs. B.P.(Brookes et al.,1985), and

4. relative sea level minimum occurred at approximately 6000 yrs B.P.(Brookes et al.,1985).

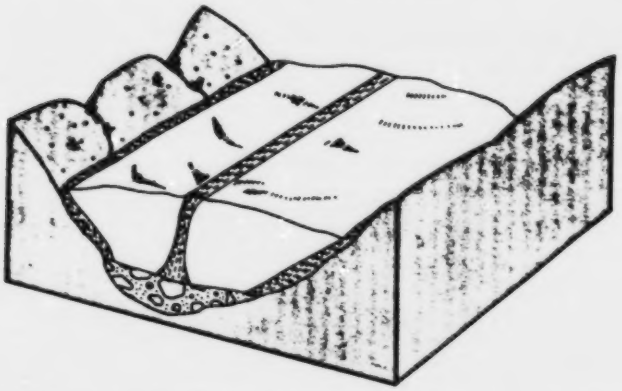
The conceptual models, presented in Figures 6 to 11, illustrate and describe the effects of deglaciation and isostatic rebound on the stratigraphy and placer potential of fluvial and marine deposits within the present study area.

CONCLUDING REMARKS

The textural, mineralogical and geochemical character of the surficial sediments within Fox Island River and east-central Port au Port Bay reflects the spatial variability inherent in differing depositional environments and in the type and relative contribution of sediment sources (e.g., glacial, fluvioglacial, marine). An accurate assessment of the placer potential in the study area cannot yet be made due to limited sample coverage, incomplete sample analysis (particularly with respect to PGE) and the lack of information upon which estimates of grades and tonnages can be based. Mineral commodities of interest include chromite, platinum, aggregate and heavy mineral byproducts (eg. zircon, rutile). Based on the available data, the strongest heavy mineral potential appears to be in the modern supratidal beach sediments where concentrations reach 98 total weight percent including approximately 7 total weight percent chromic oxide. Of further interest is facies 01 marine sands where modern concentrating mechanisms are operative and thick sand accumulations are likely to occur.

Potential zones of placer development and targets for further work may also include proglacial outwash bars, raised beach deposits and raised marine terraces. Modern fluvial placers are unlikely to occur in the upper river due to high energy flooding and removal of most sand-sized sediment from the major trunk valley. Sediment in the lower river may contain isolated zones of placer enrichment, although none were identified in the present study.

TRUNK VALLEY : GLACIAL MAXIMUM



LEGEND

- Alluvial Fan
- Basal Till
- Bedrock
- Chromite
- Glacial Ice
- Glacial Outwash
- Marine Silts and Clays
- Modern Fluvial Sediments
- Moraine
- Resedimented Morainal Material

Figure 6:

Valley glaciation during the Late Wisconsin characterized by ice scouring and dispersal of chromitiferous bedrock (i.e., the Lewis Hills ophiolite) and pre-existing sediment. Tills and morainic deposits formed. Placer deposits, if present, confined to basal tills and lateral moraines (where mutual attrition of particles is high) and occur close to source (e.g., New Zealand; Henley and Adams, 1979). Glacial tills and moraines commonly act as intermediate collectors providing ample low grade material for postglacial reworking.

TRUNK VALLEY: IMMEDIATE POST-GLACIAL

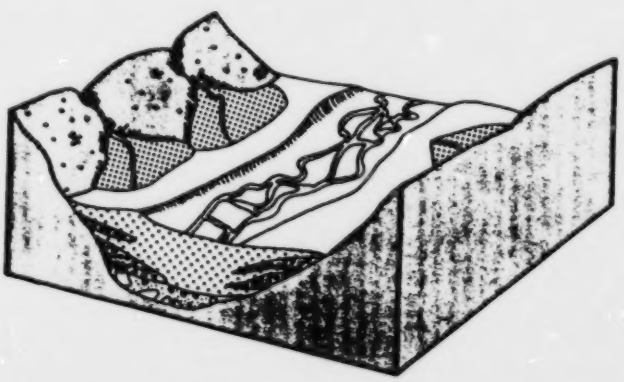
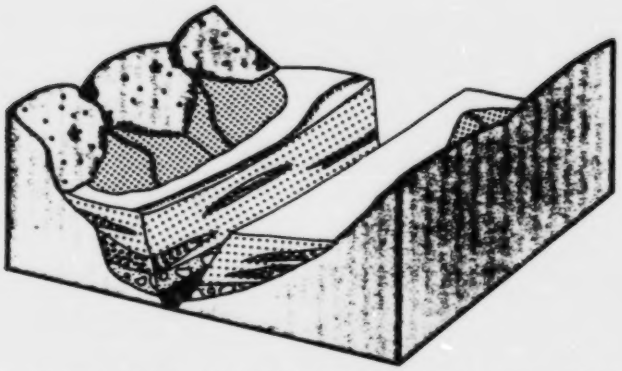


Figure 7:

Contemporaneous deposition of resedimented morainal material and glaciofluvial outwash as glacier recedes upvalley (about 14,000 yrs. B.P.). Sediment is rapidly aggraded with localized and probably very minimal sediment reworking. Placers are unlikely.

TRUNK VALLEY: PRESENT DAY



LEGEND

- Alluvial Fan
- Basal Till
- Bedrock
- Chromite
- Glacial Ice
- Glacial Outwash
- Marine Silts and Clays
- Modern Fluvial Sediments
- Moraine
- Resedimented Morainal Material

Figure 8:

Isostatic uplift associated with the ice recession results in base level lowering and fluvial incision of aggraded glacial sediments (6,000 yrs. B.P.). Fluvially transported material is flushed from the valley and deposited near the mouth of the Fox Island River and in Port au Port Bay. Placer accumulations, if present, are localized and the product of either lag entrapment within gravel interstices, or selective grain settling in response to a marked decrease in flow velocity (e.g., pockets behind boulders). Large placer deposits are unlikely due to the overall paucity of sand-sized material.

COASTAL-MARINE: GLACIAL MAXIMUM
(14000 yrs BP)

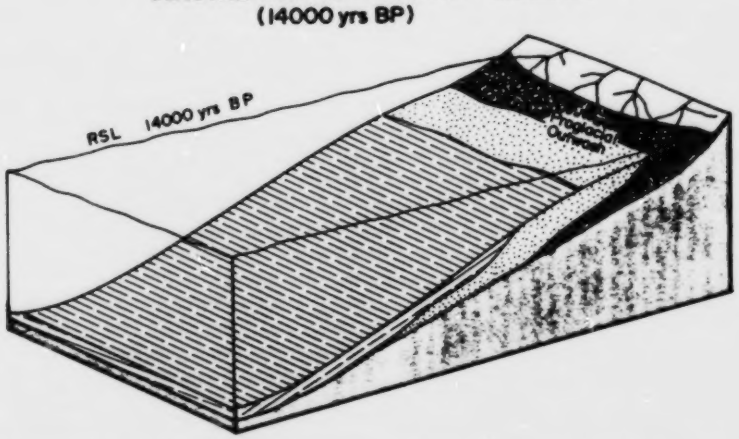
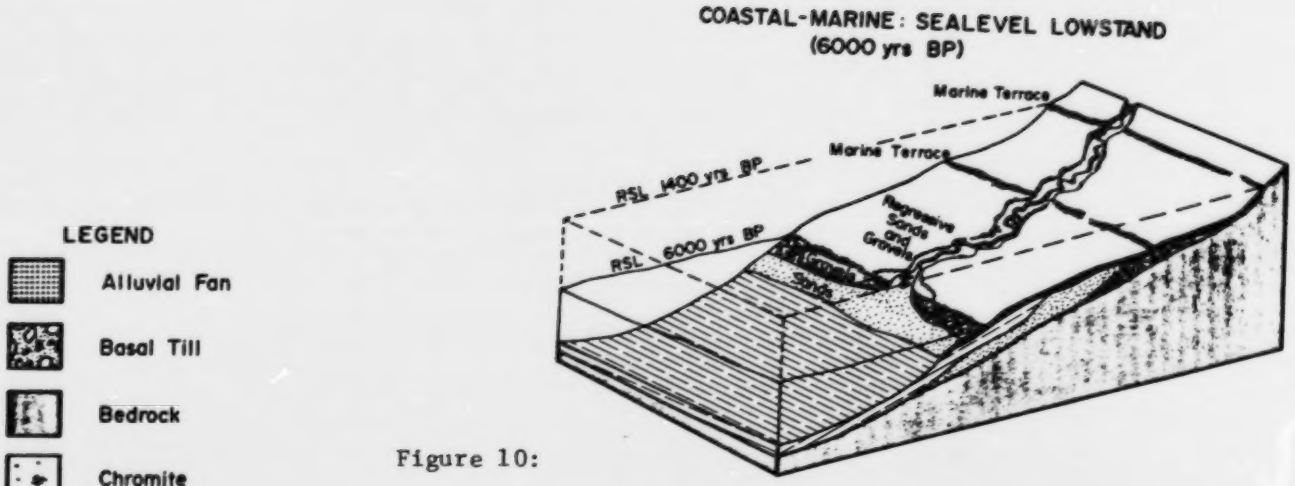


Figure 9:

Proglacial deposition and braid delta construction during the sealevel highstand (about 14,000 yrs. B.P.). Deposits generally fine downslope and fine upsection (as a result of a retreating glacial source) (cf. Miall, 1983). Some lateral variation (not illustrated) is expected as distributary channels migrate across the outwash front. Heavy mineral enrichment within discrete sand facies may occur in submarine channels, in zones of wave reworking, and in subaerial outwash on the dandur face (e.g., Baffin Island; Emory-Moore, 1986). In general, sediments aggrade rapidly with limited opportunity for reworking. Placers will thus be low grade and not a prime exploration target.



LEGEND

- Alluvial Fan
- Basal Till
- Bedrock
- Chromite
- Glacial Ice
- Glacial Outwash
- Marine Silts and Clays
- Modern Fluvial Sediments
- Moraine
- Resedimented Morainal Material

Figure 10:

Sea level regression from about 14,000 yrs. B.P. to 6,000 yrs. B.P. with a lowstand at approximately 15m below present sealevel. Outwash deposits reworked to form a residual sand and gravel lag. Marine stillstands are marked by wave-cut terraces where heavy minerals may be locally enriched (e.g. Oregon, U.S.A.; Griggs, 1945). The relatively rapid rate of sealevel regression in the study area (approximately 0.75mm/yr. may have precluded the development of mature planation surfaces and associated placer deposits.

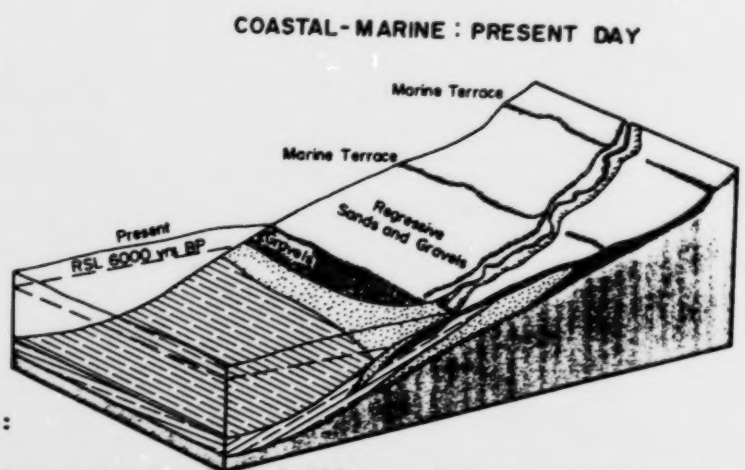


Figure 11:

A marine transgression from 6,000 yrs. B.P. to present with onlap of beach and offshore sands and gravels. Sediment sources include reworked proglacial outwash units and modern discharge from the Fox Island River. Waves and tidal current reworking may selectively concentrate heavy minerals in the beach and offshore zones (e.g., Oregon, U.S.A.; Griggs, 1945 and northern British Columbia, Canada; Barrie et. al., in prep.).

RECOMMENDATIONS FOR FURTHER WORK

The study area holds considerable economic and scientific promise. From an economic standpoint, the presence and in some instances, the abundance of chromite warrants further investigation. In addition, the results of PGE analysis are inconclusive and should be more fully addressed in future work. Specifically, the following recomendations are made:

1. a marine survey with subbottom seismic profiling and more extensive sediment sampling (including coring) to determine the lateral and vertical variability in sediment facies and chromite content: an emphasis should be placed on Facies 01 (as defined in this report),

2. planimetric profiling, trenching and sampling of the coastal beaches, particularly those areas fronted by outwash sediment derived from the Fox Island river trunk valley,

3. preliminary sampling and geochemical analysis of proglacial outwash bars, raised beaches and raised marine terraces and

4. bulk sampling (i.e., > 40 kg.) and gravity seperation of chromite-rich sands for PGE analysis.

Scientifically, the most intriguing aspect of the study area is it's confined depositional setting and thus relative simplicity with respect to the processes and patterns of chromite dispersal. Future work might entail:

1. as listed above,

2. an onshore-offshore Quaternary mapping program with a view to facies delineation and sea level history and

3. systematic geochemical mapping of the glacial and post-glacial sediment facies.

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REFERENCES

Barrie, J.V.,Emory-Moore, M., Luternauer, J. and Bornhold, B. in preparation. Origin of modern heavy mineral deposits, northern British Columbia Shelf. Submitted to Marine Geology.

Brookes, I.A., 1974. Late-Wisconsin glaciation of southwestern Newfoundland (with special reference to the Stephenville map-area). Geol. Surv. Canada Paper 73-40, 31 p.

Brookes, I.A., Scott, D.B. and McAndrews, J.H., 1985. Postglacial relative sea-level change, Port au Port area, west Newfoundland. Can. J. Earth Sci., V.22, pp. 1039-1047.

Dunsworth, S., Calon, T. and Malpas, J., 1986. Structural and magmatic controls on the internal geometry of the plutonic complex and its chromite occurrences in the Bay of Islands Ophiolite, Newfoundland. In Current Research Geological Survey of Canada Paper 86-1A, pp. 471-482.

Emery, K.O. and Noakes, L.C., 1968. Economic placer deposits of the continental shelf. Econ. Comm. Asia and Far East, Tech. Bull., V.1, pp. 95-111.

Emory-Moore, M, 1986. Textural and mineralogical characteristics of nearshore sediments, eastern Baffin Island. C-CORE Publication No.-86-2, 55pp.

Ford, R.J., 1981. Platinum-group minerals in Tasmania. Economic Geology, V.76, pp. 498-504.

Grant, D.R., 1977. Glacial style and ice limits, the Quaternary stratigraphic record, and changes of land and ocean level in the Atlantic provinces, Canada. Géogr. phys. Quat., V.XXX1, pp. 247-260.

Griggs, A.B., 1945. Chromite-bearing sands of the southern part of the coast of Oregon. U.S. Geol. Surv., Bull 945-E, 150pp.

Henley, R.W. and Adams, J., 1979. On the evolution of giant gold placers. Institution of Mining and Metallurgy, pp. B41-B50.

Legendre, O. and Auge, T., 1986. Mineralogy of platinum-group mineral inclusions in chromitites from different ophiolitic complexes". In Proceedings of the conference 'Metallogeny of Basic and Ultrabasic Rocks', Gallagher,R.A., Ixer, R.A., Neary, C.R. and Prichard, H.M. (eds.). The Institution of Mining and Metallurgy, pages 361-375.

Miall, A.D., 1983. Glacial fluvial transport and deposition. In Eyles, N.(ed.) Glacial Geology-An Introduction for Engineers and Earth Scientists. Pergamon Press, New York, pp. 168-183.

Page, N.J. and Talkington, R.W., 1984. Palladium, platinum, rhodium, ruthenium and iridium in peridotites and chromitites from ophiolite complexes in Newfoundland. Canadian Mineralogist, V.22, pp. 137-149.

Slingerland, R., and Smith, N., 1986. Occurrence and formation of water-laid placers. Ann. Rev. Planet. Sci., V.14, pp. 113-147.

Snelgrove, A.K., 1934. Chromite deposits of Newfoundland. Dept. of Natural Res., St. John's, Bull. No. 1.

Williams, H., 1975. Structural succession, nomenclature, and interpretation of transported rocks in western Newfoundland. Can. J. Earth Sci., V.12, pp. 1874-1894.

Appendix A

Analytical Data Base

sample number	% gravel	% sand	% mud	% heav c.sand	% heav f.sand	% heav sand	% heav sediment	Cr (ppm)	Ti (ppm)	Fe (ppm)	Mg (ppm)
1	3.3	95.3	1.4								
2	1.5	98.3	0.2	12.4	31	21.7	21.3				
3	71	28.6	0.4	12.6	28	26.6	7.6	2300	1000	44000	74000
4	67.4	32.3	0.26								
5	80.2	19.6	0.16	12.6	23.4	18	3.5	2400	1200	48000	74000
6	40	59.8	0.2	10.7	35.6	23.15	13.8	1800	1000	48000	80000
7	22.5	77.4	0.12								
8	11	88.6	0.43	20	19.6	19.8	17.5				
9	57.2	42.6	0.23								
10	32.5	67.4	0.1	31.2	64.4	47.8	32.2	3900	1400	53000	64000
12	0.67	99.2	0.11								
13	0.5	99.4	0.13								
14	2	97.88	0.12	5.8	54	29.9	29.3				
15	2.2	97.7	0.12	6.2	23.2	14.7	14.4				
16	2.2	97.7	0.12								
17	38	61.9	0.12								
18	58	41.6	0.4	24	22.8	23.4	9.7				
19	77	22.8	0.2	18.3	28.3	23.3	5.3	4200	1100	46000	64000
20	46.8	50.9	2.3								
21	75.4	24.5	0.11								
22	60.5	39.3	0.17	28.6	47.4	38	14.9	3600	1500	55000	75000
23	72	27.7	0.3								
24				10.4	11	10.7		2100	1000	47000	83000
25	70.4	29.3	0.29								
26	78.4	21.33	0.27	25.4	23.4	24.4	5.2	6500	1400	52000	62000
27	58.4	39.7	1.9								
28	79.3	20.6	0.11	25	71.2	48.1	9.9	5200	1200	50000	73000
29	82	17.9	0.1								
30	82	17.85	0.15	20.4	32.4	26.4	4.7				
31	63.8	35.9	0.28	20.4	67	43.7	15.7	3200	1500	50000	52000
32	42	57.4	0.6								
33	65	34.8	0.21	21	61.2	41.1	14.3	3700	1400	51000	62000
34	58.5	41.3	0.21								
35	71	28.7	0.31	21.2	23.4	22.3	6.4	4100	1500	50000	52000
36				9	10	9.5		310	1600	41000	45000
42				10.2	23.4	16.8					
53				85.8	96.4	91.1		67000	5200	130000	40000
56				15	22.4	18.7					
59				12	15.2	13.6		680	740	45000	81000
60				22.6	27.4	25					
67				15.9	20.8	18.35		3000	1200	48000	62000
74				31.4	21	26.2					
82				8.8	11.6	10.2					
84				8.2	13	10.6					
87				15.2	34.9	25.05					
90				39.2	19.4	29.3					
93				21.4	16.4	37.8					
96				22.4	19.6	21					
100				17.2	30.2	23.7		6100	1100	61000	76000
107				38.2	21.9	30.05					
108				8.4	10.3	9.35					

sample number	% gravel	% sand	% mud	% heav c.sand	% heav f.sand	% heav sand	% heav sediment	Cr (ppm)	Ti (ppm)	Fe (ppm)	Mg (ppm)
111				24.4	21.4	22.9					
116				9.2	8.4	8.8		750	1000	50000	79000
121				20.2	21.2	20.7					
122				19.8	22.4	21.1					
124				16.2	11	13.6					
127				28	20.8	28					
129				19	17.7	18.35					
131				25.5	18.3	21.9					
133				16	14.4	15.2					
139				31.6	22.8	27.2		6700	1200	60000	69000
149				12	12.2	12.1					
159				18.2	12.7	15.45		1300	720	49000	91000
169				27.4	25.9	26.65					
179				48.6	40	44.3		10000	740	63000	99000
182				18.3	10.7	14.5					
189				38.2	31	34.6					
209				31	40.2	35.6		7100	280	68000	140000
219				33.2	41.1	37.15					
229				22	34.1	28.05		3000	110	60000	140000
236				33	38.2	35.6					
240				32.4	39.4	35.9		3000	300	62000	150000
246				9.6	12	10.8					
255				28	42.3	35.15					
260				12.3	26.6	19.45					
269				17.8	28.2	23					
271				15	35	25		2300	40	50000	200000
281				45.4	35.9	40.65		18000	350	83000	170000
293				20.8	30.4	25.6		4000	50	69000	190000
295				11	13.4	12.2		3200	30	62000	210000
296				20	21	20.5					
301				24	25.6	24.8		4000	70	65000	210000
307				11.1	20.8	15.95		2500	30	48000	210000

where:

% heav. c. sand = weight % heavy minerals in the medium to coarse sands (i.e. > .250mm - 1.0mm)

% heav. f. sand = weight % heavy minerals in the fine sands (i.e. .063mm - .250mm)

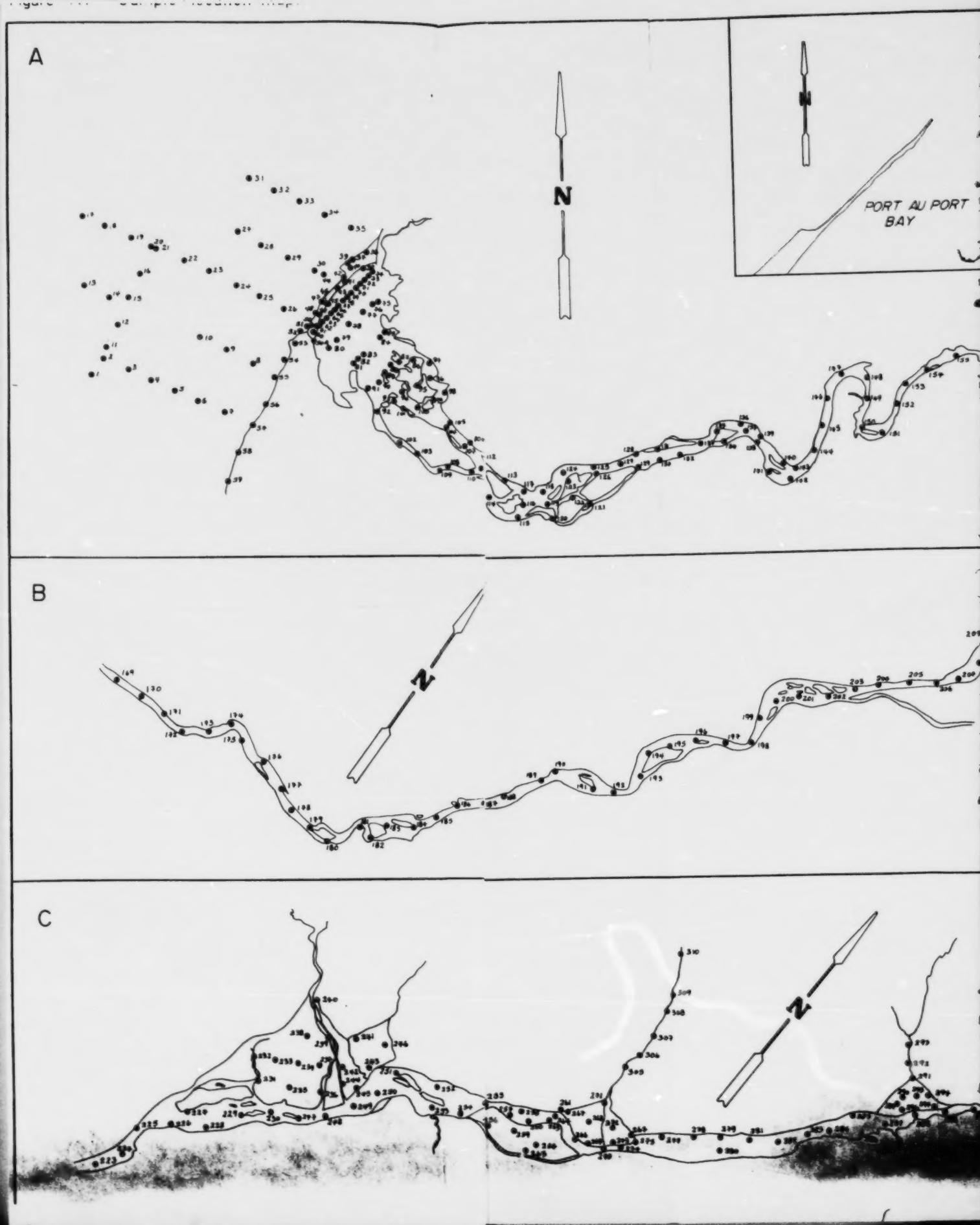
% heav. sand = average weight % heavy minerals in the total sand fraction (i.e. .063mm - 1.0mm)

% heav. sediments = total weight % heavy minerals in the sediment

sample number	2.0 mm wt. %	1.0 mm wt. %	0.5 mm wt. %	0.25 mm wt. %	0.106mm wt. %	0.063mm wt. %	<0.063mm wt. %	mean gr.sz.	sorting
42	39.8	13.2	10.8	24.7	11.2	0.42	0.36	0.58	2.83
53	0.04	0.26	9.2	71.1	19.1	0.12	0.097	0.165	1.38
59	6.8	16.7	45.2	28.8	2.6	0.11	0.09	0.38	1.41
67	40.1	11.1	22.2	22.6	3.6	0.23	0.35	0.54	2.5
119	2.5	11.8	44.1	33.4	6.3	0.99	1.5	0.27	1.43
156	22.4	47.8	26.8	2.7	0.36	0.08	0.22	0.66	1.41
182	25.3	49.6	13.4	4.2	3.6	1.7	2.4	0.8	1.53
208	24.4	43.8	22.8	7.4	2.3	0.39	0.33	0.74	1.54
225	20.7	32.8	28	12.2	3.5	1	2.4	0.6	1.65
234	11.8	32.7	26	10.7	7.1	3.3	8.2	0.43	2.06
260	13.6	27.2	33.1	17.6	6.5	1.4	0.96	0.45	1.58
268	9.3	22.3	18.2	11.5	11	8.4	19.6	0.24	1.05
295	49.3	29	13.8	4.7	2.6	0.83	0.95	1	1.76
298	23.7	43.8	28.1	4.3	0.42	0.09	0.21	0.7	1.65
307	15.1	28.5	35.9	14.1	4.12	0.96	0.82	0.45	1.55

sample number	Ru (ppm)	Rh (ppm)	Pd (ppm)	Re (ppm)	Os (ppm)	Ir (ppm)	Pt (ppm)	Au (ppm)*
53	16.25	3.27	9.69	9.35	3.05	5.53	10.71	2.71

* All values should read (ppb), not (ppm).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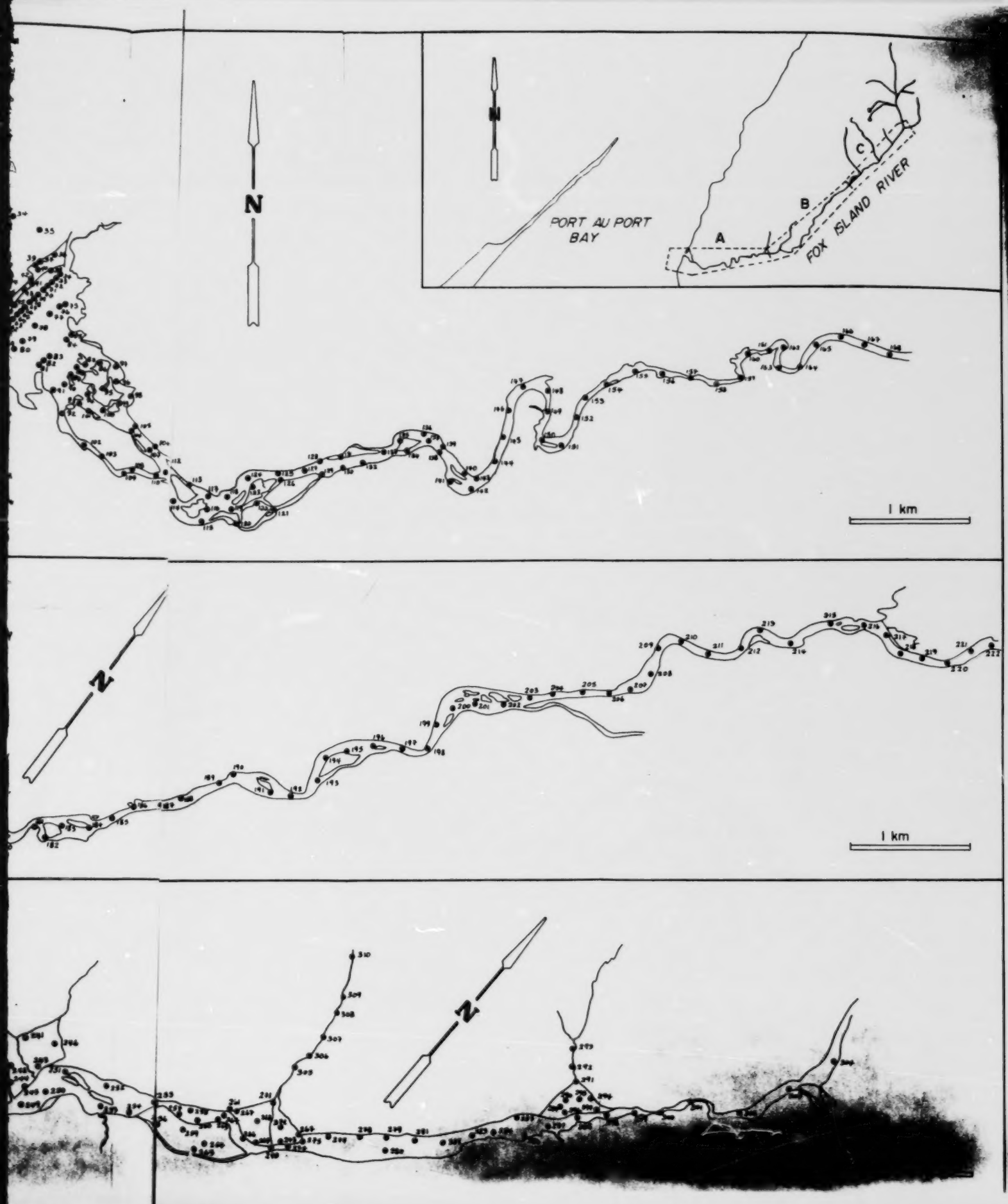
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